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DETERMINATION OF DETONATION STABILITY OF USSR AVIATION GASOLINES (GOST-3170-46)

PETROLEUM INDUSTRY B-27

The present standard applies to the determination of detonation stability (DS number) of aviation gasolines by the TsIAM (Central Scientific Research Institute of Aircraft Engine Building) which consists of a comparison of the excess air coefficients (α) in the ignition of a sample and a reference fuel in a CFR≡ASTM engine, using the intensity of detonation accepted for this method, and an established constant compression ratio.

The DS number of the fuel tested (gasoline) is determined by the difference in the excess air coefficients of the sample and the reference fuels, multiplied by 100, plus the DS number of the reference fuel, added algebraically.

NOTE: The present standard does not apply to the determination of the detonation stability of aviation gasolines where the DS number is larger than 115.

I. REFERENCE FUELS

1. Primary and secondary reference fuels are used for determining the detonation stability of aviation gasolines.

2. Chemically pure iso-octane (2, 2, 4-trimethyl pentane), with properties established by GOST 511-41, serves as primary reference fuel. This burns with the accepted detonation intensity at a constant compression ratio, corresponding to an excess air coefficient of $\alpha_1 = 0.75 \pm 0.005$. The chemically pure iso-octane is used for establishing the DS numbers of both the secondary reference fuel and aviation gasolines during the experimental tests. The DS number of chemically pure iso-octane is taken as 100.

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3. The aviation gasoline B-78 (GOST 1012-44) serves as a secondary reference fuel, and is prepared by mixing Baku B-70 straight-run distillate with technical iso-octane together with 4 ml of ethyl fluid /tetraethyl lead/ to one kilogram of gasoline. This burns with the accepted detonation intensity at the constant compression ratio established for chemically pure iso-octane, and with an excess air coefficient of $\alpha_2 = 0.80 \pm 0.01$.

The secondary reference fuel is used for establishing the DS numbers of aviation gasolines in current tests.

The DS number of the secondary reference fuel is determined relative to chemically pure iso-octane, (see Paragraph 11 of this standard) and varies within the limits of 104-106.

II. THE APPARATUS

4. The apparatus established by GOST 511-41 serves to determine the detonation stability of aviation gasolines.

5. Probe testers are used to measure fuel consumption. These consist of revamped CFR fuel containers inside of which are set metal bars, centrally located.

In establishing the volume of each probe tester, it is filled with gasoline (at a temperature of 15-20°C) to the mark at the center of the bar's lower ring. The first calibration mark is made on a glass gauge corresponding to the level of the gasoline poured in. After this is taken care of, the sampling apparatus is filled with gasoline to the mark at the center of the bar's upper ring, and a second calibration mark made on the glass gauge corresponding to the new level of gasoline.

The quantity of gasoline between the lower and upper calibration marks will constitute the volume of the tester.

The volume measurement is repeated three times, and the average value is taken as the net volume.

NOTE: It is also permissible to use water instead of gasoline in establishing the volume of the tester.

III. PREPARATION FOR THE TEST

6. Operating conditions

a. Revolutions per minute	900 ± 5
b. Coolant temperature	100 ± 2°C
c. Temperature of fuel-air mixture by mercury thermometer	150 ± 1°C
d. Composition of fuel-air mixture:	
Coefficient of excess air when operating on primary reference fuel	0.75 ± 0.01
Coefficient of excess air when operating with secondary reference fuel	0.80 ± 0.01

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e. Pressure of air entering engine — Atmospheric

f. Voltage in DC generator circuit — 110 ± 0.1

g. SU machine oil is used as lubricant, according to GOST 1707-42

Temperature of crankcase oil — 55-58°C

Oil pressure in the main line — 1.7-2.1 kg/sq cm

7. Regulating the engine

a. Valve timing is set according to Paragraph 16, GOST 511-41

b. Ignition advance is 35 degrees before top dead center (TDC) at all compression ratios

c. Breaker-point clearance is established according to Paragraph 18, GOST 511-41

d. For spark plug, see Paragraph 19, GOST 511-41

e. Detonation intensity in determining the DS numbers of the sample and reference fuels is established by a knockmeter reading of 40, with the level of the reference fuel in the sampler 20-25 millimeters above upper calibration mark from which the fuel consumption is measured.

f. The constant compression ratio of the engine is established during operation on chemically pure iso-octane with the accepted intensity of detonation, and an excess air coefficient of $\alpha_1 = 0.75 \pm 0.005$.

8. Checking the zero point of the micrometer and the setting of the Migel needle is performed according to GOST 511-41.

After setting the Migel needle, DS numbers are determined on the basis of the accepted intensity of detonation, that is, at a knockmeter reading of 40.

IV. PERFORMANCE OF THE TESTS

9. Determining the constant compression ratio

The time of outflow of the chemically pure iso-octane from the tester is measured by stop watch, with the engine running on a mixture corresponding to that for maximum detonation (excess air coefficient equals 1).

When the engine is running at the accepted intensity of detonation, a constant compression ratio is selected at which the time of iso-octane outflow through the tester equals the time of outflow at maximum detonation intensity multiplied by 0.75 ± 0.005.

This equation is obtained from the formula for computing the time (t) outflow in seconds:

$$t = \frac{\alpha \cdot G_0 \cdot V \cdot 3.6 \cdot d}{G}$$

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where:

α = Excess air coefficient

G_Q = Quantity of air necessary for complete combustion of one kilogram of fuel (in kilograms)

v = Volume of the tester (in milliliters)

d = Specific gravity of fuel at test temperature

G = Actual air consumption for the given installation (in kilograms per hour)

Substituting in this formula the respective values of the excess air coefficients and the time of iso-octane outflow through the tester with the engine running at the accepted maximum intensity of detonation, we obtain

$$t = \frac{0.75 \cdot t_1}{1}$$

where:

t = Time of iso-octane outflow from the tester at the accepted detonation intensity

0.75 = Excess air coefficient of the iso-octane at the accepted detonation intensity

t_1 = Time of iso-octane outflow at maximum intensity of detonation

1 = Excess air coefficient for iso-octane at maximum detonation intensity

NOTE: The constant compression ratio is established in these experimental tests with the engine running on the secondary-reference fuel. In this case, the constant compression ratio is that taken with the intensity of detonation obtained under an excess air coefficient of $\alpha_2 = 0.8 \pm 0.01$.

The time of outflow of the secondary reference fuel (t_2) from the tester, burning with an excess air coefficient of $\alpha_2 = 0.8$, is calculated by the formula:

$$t_2 = \frac{0.784 \cdot d_2 \cdot t.}{d_1} \qquad \text{(I)}$$

where:

d_2 = Specific gravity of the secondary reference fuel at test temperature

t_1 = Time of outflow of chemically pure iso-octane with a mixture corresponding to the maximum detonation intensity, in seconds.

d_1 = Specific gravity of chemically pure iso-octane with a mixture corresponding to the maximum detonation intensity obtained at test temperature

10. The excess air coefficient for chemically pure iso-octane (α_1) burning at the accepted detonation intensity and at the constant compression ratio, is calculated by the formula:

$$\alpha_1 = \frac{t}{t_1}$$

where:

t = Time of outflow of chemically pure iso-octane from the tester, measured in seconds, with the engine running at the constant compression ratio and the accepted intensity of detonation

t_1 = Time of outflow of chemically pure iso-octane from the tester measured in seconds, with the engine running on a mixture corresponding to maximum detonation intensity

11. Determining the DS number of the secondary-reference fuel

The time of outflow of the secondary reference fuel from the tester is determined by stop watch with the engine running at constant compression ratio and at the accepted intensity of detonation; the excess air coefficient for the secondary reference fuel α_2 is then calculated by the formula:

$$\alpha_2 = \frac{15.2 \cdot \alpha_1 \cdot d \cdot t_2}{14.9 \cdot d_2 \cdot t_1} = \frac{1.02 \cdot \alpha_1 \cdot d_1 \cdot t_2}{d_2 \cdot t_1} \qquad \text{(II)}$$

where:

15.2 = Quantity of air necessary for complete combustion of one kilogram of chemically pure iso-octane (in kilograms)

α_1 = Excess air coefficient for chemically pure iso-octane, burning under test conditions

d_1 = Specific gravity of chemically pure iso-octane at test temperature

t_2 = Time of outflow of the secondary reference fuel from the tester (in seconds), burning under test conditions

14.9 = Quantity of air necessary for complete combustion of one kilogram of secondary reference fuel (in kilograms)

d_2 = Specific gravity of the secondary reference fuel at test temperature

t_1 = Time of outflow of chemically pure iso-octane from the tester (in seconds), burning under test conditions

The arithmetical mean of three parallel tests is taken to determine the excess air coefficient of the secondary reference fuel.

The DS number of the secondary reference fuel is calculated by the formula

$$DS_2 = 100 \left[1 + (\alpha_2 - \alpha_1)\right] \qquad \text{(III)}$$

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α_1 = Excess air coefficient of chemically pure iso-octane, burning under test conditions

α_2 = Excess air coefficient of the secondary reference fuel, burning under test conditions

NOTE: The secondary reference fuel is considered suitable for the determination of DS numbers of aviation gasolines if the excess air coefficient of this fuel is $\alpha_2 = 0.8 \pm 0.01$ when burning under test conditions.

12. Determining the DS numbers of aviation gasolines

The outflow time of the test aviation gasoline and the reference fuel from the tester is determined by stop watch three times with the engine running at the constant compression ratio and accepted intensity of detonation; the excess air coefficient for the test fuel α_3 is calculated by the formula:

$$\alpha_3 = \frac{G_o' \cdot \alpha_1 \cdot d_1 \cdot t_3}{G_o''' \cdot d_3 \cdot t_1} \qquad \text{(IV)}$$

where:

G_o = Quantity of air necessary for complete combustion of one kilogram of reference fuel, equaling 15.2 kg for the chemically pure iso-octane, and 14.9 kg for the secondary reference fuel

α_1 = Excess air coefficient of the reference fuel, burning under test conditions

d_1 = The specific gravity of the reference fuel at test temperature

t_3 = Mean arithmetical time of outflow of test gasoline from the sampler (in seconds), burning under test conditions

G_o''' = Quantity of air required for complete combustion of one kilogram of test gasoline (in kilograms)

d_3 = Specific gravity of test gasoline at test temperature

t_1 = Mean arithmetical time of outflow of the reference fuel from the tester (in seconds), burning under test conditions

The DS number of the test gasoline is calculated by the following formula:

$$DS_3 = DS_1 + 100\ (\alpha_3 - \alpha_1)$$

where:

DS_1 = DS number of the reference fuel

α_3 = Excess air coefficient of the test aviation gasoline, burning under test conditions

α_1 = Excess air coefficient of the reference fuel, burning under test conditions

V. ADMISSIBLE DIFFERENCES IN PARALLEL DETERMINATIONS

13. The differences between the two parallel determinations must not exceed ± 1 DS unit.

VI. PERIODICAL CHECK-UP OF THE INSTALLATION

14. The installation should be taken apart and cleaned after every 100 hr of operation.

After the installation has been taken apart and cleaned, it must be carefully regulated according to prescribed standards.

APPENDIX

The quantity of air necessary for the complete combustion of one kilogram of fuel (G_o) is calculated by the formula

$$G_o = \frac{2.67\ C + 8H - O}{23}$$

where:

C, H and O = the respective percentage weights of carbon, hydrogen, and oxygen in the fuel, established by the empirical formula, or by analysis of the elementary composition.

The G_o value of the more widely known fuels is indicated in the following table:

Name of Fuel	Value G_o
B-70 Baku straight-run distillate aviation gasoline	14.9
B-78 aviation gasoline, prepared by mixing B-70 Baku straight-run distillate aviation gasoline with technical-grade iso-octane	14.9
Technical iso-octane	15.0
Pyrobenzene	13.8
US 130-grade aviation gasoline	14.65

Proposed by the Ministry of Aviation Industry USSR.

Approved by the All-Union Committee on Standards, as recommended, 6 May 1946.

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